DOCUMENT RESUME

ED 063 398 TM 001 725

TITLE Tool-and-Die Maker (mach. shop) 601.280--Technical Report on Development of USTES Aptitude Test Battery.

INSTITUTION Manpower Administration (DOL), Washington, D.C. U.S. Training and Employment Service.
REPORT NO TR-S-212R
PUB DATE Jun 70
NOTE 19p.

EDRS PRICE MF-$0.65 HC-$3.29
DESCRIPTORS *Aptitude Tests; *Cutting Scores; Evaluation Criteria; Job Applicants; *Job Skills; Machine Tool Operators; Metal Working Occupations; Norms; Occupational Guidance; *Personnel Evaluation; Test Reliability; Test Validity; *Tool and Die Makers
IDENTIFIERS GATB; *General Aptitude Test Battery

ABSTRACT

The United States Training and Employment Service General Aptitude Test Battery (GATB), first published in 1947, has been included in a continuing program of research to validate the tests against success in many different occupations. The GATB consists of 12 tests which measure nine aptitudes: General Learning Ability; Verbal Aptitude; Numerical Aptitude; Spatial Aptitude; Form Perception; Clerical Perception; Motor Coordination; Finger Dexterity; and Manual Dexterity. The aptitude scores are standard scores with 100 as the average for the general working population, and a standard deviation of 20. Occupational norms are established in terms of minimum qualifying scores for each of the significant aptitude measures which, when combined, predict job performance. Cutting scores are set only for those aptitudes which aid in predicting the performance of the job duties of the experimental sample. The GATB norms described are appropriate only for jobs with content similar to that shown in the job description presented in this report. A description of the validation sample and a personnel evaluation form are also included. (AG)

ED 063398

June 1970

U.S. Training and
Employment Service
Technical Report
S-212 R

Development of USTES

APTITUDE TEST
BATTERY FOR

TOOL-AND-DIE MAKER

(mach. shop)
601.280

U.S. DEPARTMENT OF LABOR
Manpower Administration

TM 001 225

Technical Report on Development of USTES Aptitude Test Battery

For . . . .

Tool-And-Die Maker (mach. shop) 601.280

S-212R

(Developed in Cooperation with the California,
Michigan and Texas State Employment Services)

U. S. Department of Labor
Manpower Administration

June 1970

FOREWORD

The United States Training and Employment Service General Aptitude Test Battery (GATB) was first published in 1947. Since that time the GATB has been included in a continuing program of research to validate the tests against success in many different occupations. Because of its extensive research base the GATB has come to be recognized as the best validated multiple aptitude test battery in existence for use in vocational guidance.

The GATB consists of 12 tests which measure 9 aptitudes: General Learning Ability, Verbal Aptitude, Numerical Aptitude, Spatial Aptitude, Form Perception, Clerical Perception, Motor Coordination, Finger Dexterity, and Manual Dexterity. The aptitude scores are standard scores with 100 as the average for the general working population, with a standard deviation of 20.

Occupational norms are established in terms of minimum qualifying scores for each of the significant aptitude measures which, in combination, predict job performance. For any given occupation, cutting scores are set only for those aptitudes which contribute to the prediction of performance of the job duties of the experimental sample. It is important to recognize that another job might have the same job title but the job content might not be similar. The GATB norms described in this report are appropriate for use only for jobs with content similar to that shown in the job description included in this report.

GATB Study #2350, 2109
and 858

DEVELOPMENT OF USTES APTITUDE TEST BATTERY

For

Tool-And-Die Maker (mach. shop) 601.280-062

S-212R

This report describes research undertaken for the purpose of developing General Aptitude Test Battery (GATB) norms for the occupation of Tool-And-Die Maker (mach. shop) 601.280-062. The following norms were established:

GATB Aptitudes	Minimum Acceptable GATB Scores
N - Numerical Aptitude	95
S - Spatial Aptitude	100
P - Form Perception	90

RESEARCH SUMMARY--VALIDATION SAMPLE

Sample

Sixty-three male Tool-And-Die Maker apprentices in California. This study was conducted prior to the requirement of providing minority group information. Therefore, minority group status is unknown.

Criterion

Supervisory ratings

Design

Concurrent (test and criterion data were collected at approximately the same time).

Minimum aptitude requirements were determined on the basis of a job analysis and statistical analyses of aptitude mean scores, standard deviations, and selective efficiencies.

Concurrent Validity

Phi coefficient (ϕ) = .51 ($P/2 < .0005$)

Effectiveness of Norms

Only 75% of the nontest-selected apprentices used for this study were good apprentices; if the apprentices had been test-selected with the above norms, 89% would have been good apprentices. Twenty-five percent of the

nontest-selected apprentices used for this study were poor apprentices; if the apprentices had been test-selected with the S-212R norms, only 11% would have been poor apprentices. The effectiveness of the norms is shown graphically in Table 1:

TABLE 1

Effectiveness of Norms

	Without Tests	With Tests
Good Workers	75%	89%
Poor Workers	25%	11%

VALIDATION SAMPLE DESCRIPTION

Size

N = 63

Occupational Status

Apprentices

Work Setting

Sample members were enrolled in the California State four-year Tool-And-Die Makers apprenticeship (8576 total hours required; 8000 hours on-the-job training; 576 hours related instruction).

Employer Selection Requirements

Age: Applicants must be between 16 and 23 years of age.
Education: High school education or its accredited equivalent.
Previous Experience: None.
Tests: None used.
Other: Physically fit for work as a Tool-And-Die Maker.

Principal Activities

The job duties for each worker are those shown in the Appendix for the validation sample.

Minimum Experience

All apprentices in the sample had completed at least one year of their apprenticeship.

TABLE 2

Means, Standard Deviations (SD), Ranges and Pearson Product-Moment Correlations with the Criterion (r) for Age and Education

	Mean	SD	Range	r
Age (years)	25.4	3.9	20-37	-.177
Education (years)	12.2	.9	10-14	.327**

**Significant at the .01 level

EXPERIMENTAL TEST BATTERY

All 12 tests of the GATB, B-1002, were administered to the validation sample during the period September 1959 to November 1960. (GATB, B-1002B was administered to 50 apprentices; GATB, B-1002A was administered to 13 apprentices.)

CRITERION

The criterion data consisted of supervisory ratings of job proficiency. The ratings and reratings were made after the apprentices had passed their second year of the apprenticeship with a time interval of two weeks between the two ratings.

Rating Scale: The Descriptive Rating Scale, Form SP-21, was used. The scale (see Appendix) consists of nine items with five alternatives for each item. The alternatives indicate the different degrees of job proficiency.

Reliability: The coefficient of correlation between the two ratings is .93 indicating good reliability. The final criterion score consisted of the combined scores of the two sets of ratings.

Criterion Score Distribution:		
	Possible Range	18-90
	Actual Range	34-89
	Mean	63.2
	Standard Deviation	11.7

Criterion Dichotomy

The criterion distribution was dichotomized into high and low groups by placing 25% of the sample in the low criterion group to correspond with the percentage of apprentices considered unsatisfactory or marginal. Apprentices in the high criterion group were designated as "good apprentices" and those in the low group as "poor apprentices". The criterion critical score was 56.

APTITUDES CONSIDERED FOR INCLUSION IN THE NORMS

Aptitudes were selected for tryout in the norms on the basis of a qualitative analysis of test and criterion data. Aptitudes F and M which do not have significant correlations with the criterion were considered for inclusion in the norms because the qualitative analysis indicated that they were important for the job duties; in addition both aptitudes had relatively high mean scores. When apprentices have already completed a large part of their apprenticeship a relatively high mean score may indicate that some sample pre-selection has taken place. Tables 3, 4 and 5 show the results of the qualitative and statistical analyses.

TABLE 3

Qualitative Analysis
(Based on the job analysis, the aptitudes indicated appear to be important to the work performed)

Aptitude	Rationale
G-General Learning Ability	Necessary to understand the principles underlying the theory courses for apprentices and to apply these principles to plan work sequence on the job.
N-Numerical Aptitude	Necessary to successfully complete mathematics courses for apprentices and to use precision instruments such as micrometers, verniers, depth gauges, etc., on the job.
S-Spatial Aptitude	Necessary to read blueprints, to do drafting and layout work, and to visualize three-dimensional objects.
P-Form Perception	Necessary to observe machine operations; to inspect work; and to fit and assemble finished parts.
F-Finger Dexterity	Necessary for deftness in making delicate adjustments and in controlling machine operations.
M-Manual Dexterity	Necessary to use hands skillfully in working with tools and instruments and in assembling machined parts by hand.

TABLE 4

Means, Standard Deviations (SD), Ranges, and Pearson Product-Moment Correlations with the Criterion (r) for the Aptitudes of the GATB

Aptitude	Mean	SD	Range	r
G - General Learning Ability	111.1	13.9	72-151	.730**
V - Verbal Aptitude	99.5	13.8	72-152	.501**
N - Numerical Aptitude	105.3	13.5	69-135	.576**
S - Spatial Aptitude	124.7	19.0	74-166	.540**
P - Form Perception	114.7	15.1	85-166	.317*
Q - Clerical Perception	104.2	13.5	80-151	.451**
K - Motor Coordination	104.5	14.0	74-140	.166
F - Finger Dexterity	115.2	17.2	85-177	.066
M - Manual Dexterity	118.1	17.0	77-159	.015

*Significant at the .05 level
**Significant at the .01 level

TABLE 5

Summary of Qualitative and Quantitative Data

Type of Evidence	Aptitudes								
	G	V	N	S	P	Q	K	F	M
Job Analysis Data Important	X		X	X	X			X	X
Irrelevant									
Relatively High Mean				X	X			X	X
Relatively Low Standard Dev.	X	X	X			X			
Significant Correlation With Criterion	X	X	X	X	X	X			
Aptitudes to be Considered for Trial Norms	G	V	N	S	P	Q		F	M

DERIVATION AND VALIDITY OF NORMS

Final norms were derived on the basis of a comparison of the degree to which trial norms consisting of various combinations of Aptitudes G, V, N, S, P, Q, F, and M at trial cutting scores were able to differentiate between the 75% of the sample considered good apprentices and the 25% of the sample considered poor apprentices. Trial cutting scores at five point intervals approximately one standard deviation below the mean are tried because this will eliminate one third of the sample with three-aptitude norms. For two-aptitude trial norms, minimum cutting scores slightly higher than one standard deviation

below the mean will eliminate about 1/3 of the sample; for four-aptitude trial norms, cutting scores slightly lower than one standard deviation below the mean will eliminate about 1/3 of the sample. The phi coefficient was used as a basis for comparing trial norms. Norms of N-95, S-100 and P-90 provided the optimum differentiation for the occupation of Tool-and-Die Maker (mach. shop) 601.280-062. The validity of these norms is shown in Table 6 and is indicated by a phi coefficient of .51 (statistically significant at the .0005 level).

TABLE 6

Concurrent Validity of Test Norms
N-95, S-100 and P-90

	Nonqualifying Test Scores	Qualifying Test Scores	Total
Good Workers	6	41	47
Poor Workers	11	5	16
Total	17	46	63

Phi coefficient (ϕ) = .51 Chi square (X^2_y) = 16.2
Significance level = $P/2 < .0005$

DETERMINATION OF OCCUPATIONAL APTITUDE PATTERN

The data for this study met the requirements for incorporating the occupation studied into OAP-34 which is shown in the 1970 edition of Section II of the Manual for the General Aptitude Test Battery. A phi coefficient of .48 is obtained with the OAP-34 norms of N-90, S-95 and P-90.

GATB Study #2109 S-212R

Tool-and-Die Maker (mach. shop) 601.280-062

Check Study #1 Research Summary

Sample

Fifty-nine apprentices of the Wilbur Wright Vocational High School, Detroit, Michigan were administered the GATB in February 1955.

TABLE 7

Means, Standard Deviations (SD), Ranges, and Pearson Product-Moment Correlations with the Criterion (r) for Age, Education, and the Aptitudes of the GATB

N = 59

	Mean	SD	Range	r
Age (years)	25.2	3.1	19-35	.095
Education (years)	11.9	.9	10-16	.051
G - General Learning Ability	114.2	14.7	85-150	.483**
V - Verbal Aptitude	104.7	15.1	72-135	.233
N - Numerical Aptitude	110.5	12.2	84-131	.396**
S - Spatial Aptitude	120.2	18.4	81-163	.600**
P - Form Perception	110.4	13.1	87-141	.406**
Q - Clerical Perception	105.5	13.7	77-129	.355**
K - Motor Coordination	100.5	18.8	45-132	.114
F - Finger Dexterity	107.3	18.6	53-143	-.015
M - Manual Dexterity	104.2	19.1	74-159	.041

**Significant at the .01 level.

Criterion

Grade-point averages based on grades for 4 courses (Mathematics, Science, Drafting and Heat Treating). Criterion data were collected in 1955.

Design

Concurrent (test and criterion data were collected at approximately the same time).

Principal Activities

The job duties for each worker are those shown in the Appendix for the validation sample.

Concurrent Validity

Phi coefficient = .40 ($P/2 < .005$)

Effectiveness of Norms

Only 66% of the nontest-selected apprentices in this sample were good apprentices; if the apprentices had been test-selected with the S-212R norms, 78% would have been good apprentices. Thirty-four percent of the nontest-selected apprentices in this sample were poor apprentices; if the apprentices had been test-selected with the S-212R norms, only 22% would have been poor apprentices. The effectiveness of the S-212R norms when applies to this sample is shown graphically in Table 8.

TABLE 8

Effectiveness of S-212R Norms on Check Study Sample #1

	Without Tests	With Tests
Good Apprentices	66%	78%
Poor Apprentices	34%	22%

TABLE 9

Concurrent Validity of S-212R Norms (N-95, S-100 and P-90) for Check Study Sample #1 (Michigan)

	Nonqualifying Test Scores	Qualifying Test Scores	Total
Good Apprentices	4	35	39
Poor Apprentices	10	10	20
Total	14	45	59

Phi coefficient (ϕ) = .40 Chi square (X^2_y) = 9.4
Significance level = P/2 $<$.005

GATB Study #858 S-212R

Tool-and-Die Maker (mach. shop) 601.280-062

Check Study #2 Research Summary

Sample

One hundred twenty-four male applicants who were subsequently employed as Tool-and-Die Makers of the Consolidated Voltee Aircraft Company, Fort Worth, Texas, were administered the GATB in 1955.

TABLE 10

Means, Standard Deviations (SD), Ranges and Pearson-Product Moment Correlations with the Criterion (r) for Age, Education, Experience, and the Aptitudes of the GATB, B-1001

N = 124

	Mean	SD	Range	r
Age (years)	23.5	4.0	19-37	-.159
Education (years)	12.1	.8	10-16	.179*
Experience (months)	10.1	7.2	1-23	.172
G - General Learning Ability	111.7	14.8	76-153	.348**
V - Verbal Aptitude	98.8	13.7	76-139	.089
N - Numerical Aptitude	107.8	14.7	68-139	.373**
S - Spatial Aptitude	118.5	16.3	69-158	.447**
P - Form Perception	111.7	15.3	76-158	.480**
Q - Clerical Perception	96.5	15.6	65-139	.281**
A - Aiming	109.3	18.8	64-159	.166
T - Motor Speed	102.5	16.6	71-155	.169
F - Finger Dexterity	104.5	18.0	57-147	.226*
M - Manual Dexterity	122.4	17.4	80-169	.302**

*Significant at the .05 level
**Significant at the .01 level

Criterion

Supervisory ratings (3broad categories). Criterion data were collected in 1956.

Design

Longitudinal (tests were administered to applicants and criterion data were obtained after workers had been on the job long enough to be validly rated with regard to their proficiency).

Principal Activities

The job duties for each worker are those shown in the Appendix for the validation sample.

Predictive Validity

Phi coefficient (ϕ) = .42 ($P/2 < .0005$)

Effectiveness of Norms

Only 67% of the nontest-selected workers in this sample were good workers; if the workers had been test-selected with the S-212R norms, 84% would have been good workers. Thirty-three of the nontest-selected workers were poor workers; if the workers had been test-selected with the S-212R norms, only 16% would have been poor workers. The effectiveness of the S-212R norms when applied to this sample is shown in Table 11.

TABLE 11

Effectiveness of S-212R Norms on Check Study Sample #2

	Without Tests	With Tests
Good Workers	67%	84%
Poor Workers	33%	16%

TABLE 12

Predictive Validity of S-212R Norms for Check Study #2 (Texas)
N-95, S-100 and P-90

	Nonqualifying Test Scores	Qualifying Test Scores	Total
Good Workers	21	62	83
Poor Workers	29	12	41
Total	50	74	124

Phi coefficient (ϕ) = .42
Significant level = $P/2 < .0005$

Chi square (X^2_y) = 21.7

SP-21

A-P-P-E-N-D-I-X

DESCRIPTIVE RATING SCALE
(For Aptitude Test Development Studies)

Score____

RATING SCALE FOR _____
D. O. T. Title and Code

Directions: Please read Form SP-20, "Suggestions to Raters", and then fill in the items listed below. In making your ratings, only <u>one</u> box should be checked for each question.

Name of Worker (print) _____
(Last) (First)

Sex: Male_____ Female_____

Company Job Title: _____

How often do you see this worker in a work situation?

☐ See him at work all the time.

☐ See him at work several times a day.

☐ See him at work several times a week.

☐ Seldom see him in work situation.

How long have you worked with him?

☐ Under one month.

☐ One to two months.

☐ Three to five months.

☐ Six months or more.

A. How much work can he get done? (Worker's <u>ability</u> to make efficient use of his time and to work at high speed.)

☐ 1. Capable of very low work output. Can perform only at an unsatisfactory pace.

☐ 2. Capable of low work output. Can perform at a slow pace.

☐ 3. Capable of fair work output. Can perform at an acceptable but not a fast pace.

☐ 4. Capable of high work output. Can perform at a fast pace.

☐ 5. Capable of very high work output. Can perform at an unusually fast pace.

B. How good is the quality of his work? (Worker's ability to do high-grade work which meets quality standards.)

☐ 1. Performance is inferior and almost never meets minimum quality standards.

☐ 2. The grade of his work could stand improvement. Performance is usually acceptable but somewhat inferior in quality.

☐ 3. Performance is acceptable but usually not superior in quality.

☐ 4. Performance is usually superior in quality.

☐ 5. Performance is almost always of the highest quality.

C. How accurate is he in his work? (Worker's ability to avoid making mistakes.)

☐ 1. Makes very many mistakes. Work needs constant checking.

☐ 2. Makes frequent mistakes. Work needs more checking than is desirable.

☐ 3. Makes mistakes occasionally. Work needs only normal checking.

☐ 4. Makes few mistakes. Work seldom needs checking.

☐ 5. Rarely makes a mistake. Work almost never needs checking.

D. How much does he know about his job? (Worker's understanding of the principles, equipment, materials and methods that have to do directly or indirectly with his work.)

☐ 1. Has very limited knowledge. Does not know enough to do his job adequately.

☐ 2. Has little knowledge. Knows enough to "get by."

☐ 3. Has moderate amount of knowledge. Knows enough to do fair work.

☐ 4. Has broad knowledge. Knows enough to do good work.

☐ 5. Has complete knowledge. Knows his job thoroughly.

E. How much aptitude or facility does he have for this kind of work? (Worker's adeptness or knack for performing his job easily and well.)

☐ 1. Has great difficulty doing his job. Not at all suited to this kind of work.

☐ 2. Usually has some difficulty doing his job. Not too well suited to this kind of work.

☐ 3. Does his job without too much difficulty. Fairly well suited to this kind of work.

☐ 4. Usually does his job without difficulty. Well suited to this kind of work.

☐ 5. Does his job with great ease. Exceptionally well suited for this kind of work.

F. How large a variety of job duties can he perform efficiently? (Worker's ability to handle several different operations in his work.)

☐ 1. Cannot perform different operations adequately.

☐ 2. Can perform a limited number of different operations efficiently.

☐ 3. Can perform several different operations with reasonable efficiency.

☐ 4. Can perform many different operations efficiently.

☐ 5. Can perform an unusually large variety of different operations efficiently.

G. How resourceful is he when something different comes up or something out of the ordinary occurs? (Worker's ability to apply what he already knows to a new situation.)

☐ 1. Almost never is able to figure out what to do. Needs help on even minor problems.

☐ 2. Often has difficulty handling new situations. Needs help on all but simple problems.

☐ 3. Sometimes knows what to do, sometimes doesn't. Can deal with problems that are not too complex.

☐ 4. Usually able to handle new situations. Needs help on only complex problems.

☐ 5. Practically always figures out what to do himself. Rarely needs help, even on complex problems.

H. How many practical suggestions does he make for doing things in better ways? (Worker's ability to improve work methods.)

☐ 1. Sticks strictly with the routine. Contributes nothing in the way of practical suggestions.

☐ 2. Slow to see new ways to improve methods. Contributes few practical suggestions.

☐ 3. Neither quick nor slow to see new ways to improve methods. Contributes some practical suggestions.

☐ 4. Quick to see new ways to improve methods. Contributes more than his share of practical suggestions.

☐ 5. Extremely alert to see new ways to improve methods. Contributes an unusually large number of practical suggestions.

I. Considering all the factors already rated, and <u>only</u> these factors, how acceptable is his work? (Worker's "all-around" ability to do his job.)

☐ 1. Would be better off without him. Performance usually not acceptable.

☐ 2. Of limited value to the organization. Performance somewhat inferior.

☐ 3. A fairly proficient worker. Performance generally acceptable.

☐ 4. A valuable worker. Performance usually superior.

☐ 5. An unusually competent worker. Performance almost always top notch.

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FACT SHEET

Job Title: Tool-and-Die Maker (mach. shop) 601.280-062

Job Summary: Constructs and repairs metal-forming tools, dies, jigs, fixtures, and gages, shaping the parts with various metal-working machines and fitting them together with machinist's hand tools.

Work Performed: Determines work procedure. Studies blueprints, models, work sketch, or other instruction to determine specifications for new tool, die, jig, fixture, or gage. Selects suitable stock and lays out work-piece for initial cutting operations by establishing center and reference points and guide lines, using rule, surface gages, dividers, protractor, and marking devices such as power hacksaw, milling machine, planer, or shaper, engine lathe or turret lathe, drill press, jig borer or boring mill, and internal, surface, or universal grinders.

Sets up and operates machines to produce tool, die, jig, or gage parts to fine tolerances: Establishes additional reference points and guide lines on work piece; sets up work piece in appropriate machine by fastening it onto machine table, securing it between centers, or fastening it into jig or fixture. May build up holding device, using wood or metal blocks, straps, bolts, or clamps. Installs dividing head, if required, as on a milling machine, to make accurately spaced cuts at precise angles; bolts or clamps cutting tool to tool carriage of machine; turns crank or hand-wheel to bring work or tools into position for each cut. Moves levers, shifts belt or gears to control speed and feed of machine; moves control lever or switch to start machine and observes operation. Stops machine at intervals to inspect work and make measurements with scale, calipers, micrometer, or other gages.

Fits and assembles finished parts: Chips, files, scrapes and polishes surfaces of machined parts, finishing them to very close tolerance, with hand tools such as chisel, file, and scraper. Assembles parts and fastens them together with screws and bolts; may weld or braze parts during assembly. Checks completed tool, die, jig, fixture, or gage, using precision measuring instruments, for conformity to original specifications, and makes necessary alterations.

Repairs and maintains tools, dies, jigs, fixtures, and gages: Examines worn tool or die to determine nature of repair necessary; disassembles it and performs required machining operations on parts. Makes replacement parts if required, following original specifications. Reassembles parts. Checks accuracy of gages and measuring devices using standard gages such as Johansson blocks and makes required adjustments with hand tools to bring gage or device within accuracy limits specified.

Takes routine care of machine tools: Cleans, oils, and makes minor adjustments and repairs, or reports condition of machine to maintenance department.

As required, performs related tasks: Designs dies, tools, jigs, fixtures, and gages; makes clay, glass, wood, or metal models in the process of developing tools, dies, jigs, fixtures, and gages; heat-treats metal parts by heating in a furnace to specified temperature and quenching them in oil or water or letting them cool slowly. May give on-job training to Tool-and-Die Maker Apprentice.

Effectiveness of Norms

Only 75% of the nontest-selected apprentices used for this study were good apprentices; if the apprentices had been test-selected with the S-212R norms, 89% would have been good apprentices. Twenty-five percent of the nontest-selected apprentices used for this study were poor apprentices; if the apprentices had been test-selected with the S-212R norms, only 11% would have been poor apprentices. (Validation sample)

Only 66% of the nontest-selected apprentices used for this study were good apprentices; if the apprentices had been test-selected with the S-212R norms, 78% would have been good apprentices. Thirty-four percent of the nontest-selected apprentices used for this study were poor apprentices; if the apprentices had been test-selected with the S-212R norms, only 22% would have been poor apprentices. (Cross-validation sample #1)

Only 67% of the nontest-selected workers used for this study were good workers; if the workers had been test-selected with the S-212R norms, 84% would have been good workers. Thirty-three percent of the nontest-selected workers used for this study were poor workers; if the workers had been test-selected with the S-212R norms, only 16% would have been poor workers. (Cross-validation sample #2)

Applicability of S-212R Norms

The aptitude test battery is applicable to jobs which include a majority of duties described above.

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